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**EXPLORING THE EFFECTS OF POPULATION CHANGE  
ON THE COSTS OF PHYSICIAN SERVICES**

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ABSTRACT

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The effects of population aging on future health care costs are an important public policy concern in many countries. We focus in this paper on physician services and investigate how changes in the size and age distribution of a population can affect the aggregate and per capita costs of such services. The principal data set (unpublished, for Ontario) provides information about payments to physicians, by age and sex of patients. Using it, we derive age/cost profiles for 19 categories of physicians. Adopting an index-theoretic framework, we then use the profiles to analyse the “pure” effects of population change (historical or projected) on physician costs, and to decompose the effects into population growth effects and population aging effects. We present calculations for Ontario, for the populations of 15 industrialized countries, and for four theoretical populations.

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1. INTRODUCTION

Population aging is common throughout the industrialized world. In only a few countries are total fertility rates close to the natural replacement level (about 2.1 children per woman), and in most they are well below that level, thus inhibiting the growth of the population and causing long-term changes in its age distribution. The proportions over 60 or 65 are rising, the proportions under 15 are falling, and these trends are projected to continue far into the future. Circumstances vary from country to country but virtually all share this one demographic characteristic: their populations are growing older.

The aging of a population has far-reaching economic implications. It has implications for patterns of consumption, saving, and investment in the economy, for the level and rate of growth of the national product, and for per capita national income. It has implications for the rates of

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flow of young workers into the labour force and the rates of retirement, for pensions at one end of the age spectrum and for enrollment in schools and universities at the other, for the levels and composition of government budgets, and of course for the health care system.

Every aspect of the health care system is affected in one way or another by changes in the population, including the requirements for physicians, nurses and other skilled personnel, the demand for hospital beds and equipment, and the need for long-term institutional care facilities and for home care services for the elderly. The cost implications of such changes are prominent in discussions of public policy, in light of the now widely recognized aging trend. But such discussions often go not much further than emphasizing aging as a source of future increases in health care costs; they frequently display little understanding of the likely timing and magnitude of aging effects. Questions of “when” and “how much” seem not to have received the attention they deserve. At least that is our impression, based on observations of policy discussions in Canada.

One would like a comprehensive assessment of the effects of population change on all parts of the health care system. However, our objective in this paper is more modest. We focus on physicians, in particular on the effects of population change on the overall costs of physician services. In doing so we take advantage of a detailed set of data on billings by fee-for-service physicians in the province of Ontario, classified by age and sex of patient and category of physicians. The data set (unpublished) relates to the fiscal year 1995-96 (hereafter referred to usually as 1995). It was provided to us by the Canadian Institute for Health Information, and was compiled from records of the Ontario Health Insurance Plan (OHIP). Physicians paid by OHIP on a fee-for-service basis represented almost all physicians in clinical practice in Ontario in 1995,

and the data set is thus comprehensive and well suited for our purposes. (OHIP fee-for-service payments to physicians represented about 98 percent of all payments received by physicians in Ontario in the 1995-96 fiscal year; see Canadian Institute for Health Information, 1998.) Using this data set, coupled with Statistics Canada 1995 population figures, we have constructed age/cost profiles for Ontario – profiles representing the per capita costs of services provided to the male and female populations, by five-year age groups, for each physician category. We apply those profiles in studying the past and future effects of population change in Ontario. We apply them also to the projected populations of fifteen selected countries, and to four theoretical populations, to investigate demographic effects on physician costs more generally. (Earlier studies in which age profiles were employed in health care analysis and projections include Denton, Gafni, and Spencer, 1992, 1993, 1994, 1995a, 1995b, for Ontario, and Greenberg and Cultice, 1997, for the U.S.)

The paper proceeds as follows. We begin with a brief review of the demographic situation in Ontario, focusing on historical and projected rates of population growth and summary measures of age distribution, and then turn to a display and interpretation of the 1995 Ontario age/cost profiles. Next we develop a framework for calculating the “pure” effects of population change on the aggregate cost of physician services, and for separating the overall effects into those attributable to population growth and those attributable to changes in age distribution. The framework is then used in applications of the age/cost profiles to the Ontario population, historical and projected, and subsequently to the projected populations of the fifteen countries and the four theoretical populations. Lastly, we return to Ontario and examine the effects of population change on the individual categories of physicians.

## 2. GROWTH AND AGING OF THE ONTARIO POPULATION

We start with a review of population change in Ontario, as background to our later consideration of its effects on physician costs. Table 1 provides some summary measures – size, rates of growth, median age, and proportions in selected age groups. Figure 1 provides plots of the growth rates, median age, and age proportions. In both cases the series shown extend from 1960 to 2000, and then to 2040, based on projections that we have made. (The projection program is the one for Canada described in Denton, Feaver, and Spencer, 1994, extended to allow provincial population projections.) They thus cover a period that has seen major shifts in fertility patterns, immigration levels, and life expectancy, and will have seen, by the time it is over, profound changes in the population age distribution. A rough dating of the “baby boom” in Canada, and in Ontario, its largest province, would be from the mid 1940s to the mid 1960s. The children of that period are now in early to late middle age; by 2020 they will all be over 55, and subject to the health care requirements associated with an older population. Hence the concern about what will happen to national and provincial health care budgets.

We offer three projections. Projection A, which we refer to as “standard”, assumes that the most recent available total fertility rate of about 1.5 children per woman will continue throughout the projection period, that mortality rates will change in such a way as to increase life expectancy at birth by about 5 years for males by the end of the period, and 2.5 years for females, that immigration to Canada will be 225 thousand per year (consistent with announced government target levels), that interprovincial net migration to Ontario will be in accordance with recent average levels, and that emigration to other countries will also be in accordance with

recent levels. This may be regarded as a “best guess” projection, given present information.

Projection B is a “younger population” projection: it assumes that by 2020 the total fertility rate will rise to 2.1 (the natural replacement level), that life expectancies will rise somewhat more slowly, and that immigration to Canada will be at a level of 275 thousand per year. Projection C is an “older population” projection: by 2020 the total fertility rate falls to 1.2 (the lowest recent observed rate in any of the European Union countries), life expectancies rise somewhat more rapidly than in Projection A, and immigration to Canada is reduced to 175 thousand per year.

The rate of growth of the population in Ontario (as in Canada as a whole) has fluctuated from year to year, depending on variations in immigration. In Projection A, the future trajectory of the growth rate is sharply downward, reflecting the continuing low fertility rate, and in Projection C the rate declines even faster, falling to zero by 2040. Even in Projection B, with its much higher level of annual immigration, the fall in the growth rate is merely delayed for two decades. As the rate of growth slows, the proportion of older people increases, while the proportion of children either falls continuously (Projections A and C), or falls and then returns to approximately its current level (Projection B). Concomitantly, the median age of the population rises, more or less rapidly, depending on which projection one looks at. Having it in mind that people 55 and over are well above average in their health care requirements, we note that the 55+ population as a percentage of the total has been increasing steadily since 1960, and that it is going to increase markedly in the next several decades, whichever projection one looks at. In the year 2000 the 55+ population was about 22 percent of the total; in the year 2040 it is projected to be in the range 30 to 40 percent, with a “best guess” (Projection A) figure of 36 percent. The very high health care utilization age group, 75 and older, is projected to increase from less than 6

percent of the total in 2000 into the range 10 to 15 percent by 2040.

### 3. AGE AND THE COSTS OF PHYSICIAN SERVICES

We turn now to an examination of the relationships between age and the costs of physician services. Age/cost profiles are displayed in Figure 2 for nineteen categories of physicians (an exhaustive set), and for all categories combined. A profile is interpreted as the average cost per member of the population in a 5-year age group for the use of the services of physicians in a given category. Some members of the age group will use those services during the course of a year, some will not. In Ontario almost all costs are billed to the Ontario Health Insurance Plan as fees for services provided.

The male and female profiles for all physician categories combined show the cost per capita to be generally rising with age, faster for women than for men through young adult and middle age, faster for men than for women in old age. The profiles fall off a little, though, near the end of the life span. (That is not to say that total health care costs turn down; the decline in physician costs may be offset by increases in hospital, long-term care, and home care costs.) The profiles for General Practice are similar in shape to the All Categories profiles, except that they do not show the declines at the oldest ages. The profiles for the majority of specialties show a generally increasing pattern over most of the life span, but there are exceptions. Among the more obvious ones are Pediatrics and Obstetrics/Gynecology. Psychiatry shows a rough sort of bell shape, reaching peaks in the 40s and falling off steadily thereafter. There are pronounced differences between male and female profiles in some cases – in Thoracic/Cardiovascular Surgery, Urology, and Psychiatry, to take three conspicuous examples.

The age/cost profiles can be used to calculate the implied percentage age distribution of



total cost for the population as a whole. We have done that for four different populations and the results are shown in Figure 3. The populations are a theoretical stationary population derived from the 1991 Statistics Canada life tables for Ontario, the actual Ontario population in 2000, and the Projection A populations for 2020 and 2040. For the actual 2000 population, the percentage share of total cost peaks in the 35-39 age group, although it is relatively flat through to the early 50s. That suggests that if, hypothetically, the usage of physician services per person could be reduced over some age range by, say, 5 percent, the greatest impact on total costs would be realized for the population 35 to 55 (because of its size), not by the older population, as might have been supposed (in spite of its much greater per capita requirements for physician services).

The cost distribution pattern can be expected to shift as time passes and the baby boom cohort moves along its age path. By 2020 the distribution is projected to be at its highest level for ages 55 to 75, and by 2040 it develops a sharp peak at around 75. While the greatest cost gains today would come from reductions of usage by persons of middle age, in the coming decades the greatest gains will be associated with reductions by people in the older range.

The shape of the distribution for the stationary life table population is generally similar to that of the projected 2020 population. We note that in passing as a perhaps curious fact, given the quite different origins of the two populations.

#### 4. A FRAMEWORK FOR CALCULATING THE EFFECTS OF POPULATION CHANGE

The framework for calculating the effects of population change on physician costs is as follows. Let  $t$  denote time (year) and let  $C(p,0)$  denote the total cost of all services provided by physicians in category  $p$  in some base year  $t = 0$  (1995 in our calculations).  $C(p,0)$  is

calculated as

$$(1) \ C(p,0) = \sum_j \sum_x c(p,j,x,0) N(j,x,0) \quad (p = 1, 2, \dots, 19)$$

where  $c$  denotes cost per capita,  $j$  sex ( $j = 1, 2$ ),  $x$  age group ( $x = 0-4, 5-9, \dots, 90+$ ), and  $N$  population.  $C(p,0)$  is thus a function of the category  $p$  age/cost profile (the  $c$  parameters, as plotted in Figure 2) and the corresponding age group populations. The total cost for all physician categories combined in the base year is  $C(0) = \sum C(p,0)$ .

Assume now that the age/cost profiles are held constant and that only the age-sex group populations change through time. An index of the “pure” effects of population change on the cost of category  $p$  services is then

$$(2) \ H(p,t) = \left( \sum_j \sum_x c(p,j,x,0) N(j,x,t) \right) \Bigg/ \left( \sum_j \sum_x c(p,j,x,0) N(j,x,0) \right)$$

with value 1 at  $t = 0$ . The corresponding index for all categories combined is

$$(3) \ H(t) = \left( \sum_p \sum_j \sum_x c(p,j,x,0) N(j,x,t) \right) \Bigg/ \left( \sum_p \sum_j \sum_x c(p,j,x,0) N(j,x,0) \right)$$

$$= \sum_p w(p,0) H(p,t)$$

where  $w(p,0) = C(p,0) / C(0)$ . Holding the age/cost profiles constant implies that costs are defined in “real” (constant price) terms, and that there is no change in the patterns of utilization of physician services at given ages, including changes brought about by advances in medical knowledge, new technology, and changes in physician practice norms. Needless to say, utilization patterns have changed, and will change in the future. However, we are interested here only in the “pure” effects of population change; hence the everything-else-constant assumption.

Equations (2) and (3) will be recognized as applications of the Laspeyres quantity index formula familiar in price/quantity index theory (Banerjee, 1975, for example). Prices in that context are replaced here by the age/cost parameters ( $c$ ), quantities purchased are replaced by the populations ( $N$ ), and the  $p, j, x$  subscripts play the role of identifiers of different “commodities”. (There are 19 physician categories in our calculations, 2 sexes, and 19 age groups; thus there are 722 “commodities” in total.)

## 5. SEPARATION OF AGING AND GROWTH EFFECTS

Rates of growth of the  $H(p,t)$  and  $H(t)$  indexes can be calculated and the rates can be separated into two components, one associated with population growth (holding constant the composition of the population), the other with changes in composition (holding constant the size of the population). There has been much concern about the effects of population aging as a source of great pressure on the health care system in the future, but little attention has been paid to the effects of population growth; at least that is our impression, based on policy discussion in Canada. Identification of the separate effects and an assessment of their relative magnitudes thus seems to us of some interest.

Let  $N(t) = \sum_j \sum_x N(j, x, t)$  be the total population in year t and let  $n(j, x, t)$  be the

proportion of the total that is in age group x and of sex j.  $N(j, x, t)$  and  $N(j, x, 0)$  can be replaced in equation (2) by  $N(t)n(j, x, t)$  and  $N(0)n(j, x, 0)$ . Straightforward manipulation of the equation then allows us to write  $H(p, t) = G(t)D(p, t)$ , where  $G(t) = N(t) / N(0)$  represents the contribution of population growth to the category p cost index and  $D(p, t)$  represents the contribution of changes in age-sex distribution.  $D(p, t)$  is defined by

$$(4) \quad D(p, t) = \left( \sum_j \sum_x c(p, j, x) n(j, x, t) \right) / \left( \sum_j \sum_x c(p, j, x) n(j, x, 0) \right)$$

The rate of change of the  $H(p, t)$  index can be separated too into growth and distribution components. Define  $\Delta$  as the difference operator over some specified time interval. The change in the index can then be decomposed as follows:

$$(5) \quad \begin{aligned} \Delta H(p, t) &= (G(t) + \Delta G(t))(D(p, t) + \Delta D(p, t)) - G(t)D(p, t) \\ &= G(t)\Delta D(p, t) + D(p, t)\Delta G(t) + \Delta G(t)\Delta D(p, t) \end{aligned}$$

Dividing through by  $H(p, t) = G(t)D(p, t)$ , and canceling terms, yields

$$(6) \ h(p,t) = g(t) + d(p,t) + g(t)d(p,t)$$

where  $h(p,t) = \Delta H(p,t) / H(p,t)$

$$g(t) = \Delta G(t) / G(t)$$

$$d(p,t) = \Delta D(p,t) / D(p,t) .$$

Based on a result from elementary calculus, the term  $g(t)d(p,t)$  tends to zero as the time interval narrows. If the interval is positive but short, the term remains but is of “small order”, so that the approximation  $h(p,t) \cong g(t) + d(p,t)$  is close, with an error of approximation equal to  $g(t)d(p,t)$ .

Changes in the index  $H(t)$  can be decomposed in the same way. First, the index can be expressed as  $H(t) = G(t)D(t)$ , where  $D(t) = \sum w(p,0)D(p,t)$ . Then the rate of change of the index can be approximated by  $h(t) \cong g(t) + d(t)$ , with error of approximation  $g(t)d(t)$ .

The errors of approximation result from the interaction of the two components  $g(t)$  and  $d(p,t)$ , or  $g(t)$  and  $d(t)$ . A reasonable procedure is to assign them in equal parts to both, and we do that in the tables that follow in which we report 5-year growth rates. (A check shows that the resulting adjustments to the components never exceed a tenth of a percentage point.)

## 6. EFFECTS OF POPULATION CHANGE ON PHYSICIAN COSTS IN ONTARIO

We turn now to the case of Ontario, making use of the framework developed above. Holding constant the age/cost profiles for physician services, we calculate what aggregate costs and per capita costs would have been in the last four decades of the 20<sup>th</sup> century, with only the population allowed to vary, and what they would be in the first four of the 21<sup>st</sup>, based on the three alternative population projections presented previously. The results are shown in Table 2. Indexes of costs for all categories of physicians combined are shown, first for aggregate costs and then for costs per member of the population. The indexes have base value 100.0 in the year 2000. (The time base is arbitrary; 2000 is chosen merely as a convenient reference year.) Also shown are five-year rates of growth of the aggregate cost indexes, and the decomposition of those rates into population growth and population aging components. (Strictly speaking, the latter should be interpreted as the result of changes in both the age and sex distribution of the population. However, the effects of changes in sex distribution are negligible and it is convenient to use the term population aging.) Note that the population aging component can also be interpreted as the rate of growth of the per capita cost index, since dividing by the total population removes the effect of changes in the size of the population, leaving only the effect of changes in its composition.

Population change would be responsible for an increase of 59 percent in the total cost of physician services between 2000 and 2040, under the assumptions of Projection A. That compares with 111 percent over the period 1960 to 2000. The projected 40-year increase in total cost is somewhat greater for Projection B (with its higher rates of fertility, mortality, and immigration) and somewhat smaller for Projection C (with its lower rates in all three categories).

But in no case does the increase come close to that of the 1960-2000 period. A similar conclusion holds for comparisons of the future and most recent 20-year periods, 2000-2020 and 1980-2000: the projected increase is lower than the historical one, whichever projection one looks at. Narrowing the focus further, the projected growth of total physician costs is roughly the same in the decade 2000-2010 as in the decade 1990-2000 -- 15-18 percent compared with 17 percent. The conclusion is clear then: placed in historical context, and contrary to popular belief, the effect of population change on the rate of growth of aggregate physician costs in Ontario is unlikely to increase in the first decade of this century, and likely to decrease appreciably in subsequent decades.

The overall per capita cost of physician services may rise more rapidly in the future as a consequence of aging. Per capita cost increased by about 8 percent between 1980 and 2000. It is projected to increase by close to 10 percent between 2000 and 2020 according to projection A, and close to 12 percent according to Projection C . By 2040, Projection A produces an increase of 18 percent over the 2000 level, Projection C an increase of almost 25 percent -- large increases, unquestionably, and greater than the 12 percent rise recorded for the comparable period 1960 to 2000. Projection B, on the other hand, produces significantly lower rates of increase -- ones below the historical rates, so the possibility remains open that per capita cost will rise less rapidly in the future than in the past. While they disagree on how much, though, all three projections agree that the per capita cost of physician services will rise over the next four decades.

Population aging certainly matters. The baby boom generation is moving towards retirement and the years of higher demands on the health care system while fertility rates remain

well below the natural replacement level, and thus restrict the numbers of children -- and later the numbers of young adults -- in the population. What seems not to be well appreciated, though, is the fact that while the baby boom/baby bust sequence is responsible for the unprecedented large bulge in the age distribution and the phenomenon of population aging that claims so much attention in policy discussion and prognostication, it is responsible also for slowing the rate of growth of the population. There are thus two effects on the rate of increase of overall physician costs, acting in opposite directions. On the one hand, aging tends to raise the rate of increase; on the other, slower population growth tends to lower it.

How do these two effects play out against each other? Looking again at Table 2, it is clear that changes in the size of the population were by far the most important cause of increases in aggregate physician costs during the last four decades of the 20<sup>th</sup> century. The dominance of the growth influence is evident for every 5-year interval of the period, and as recently as 1995-2000 it accounted for 6.6 of the overall increase of 8.3 percent in aggregate cost, while aging accounted for only 1.7. According to Projections A and B, population growth will continue to be the most important factor right through to 2040. Indeed if, as in Projection B, the total fertility rate were to rise to the natural replacement level of 2.1 children per woman – about where it is in the United States today – and mortality and immigration rates were to be higher also, then the effect of population aging on physician costs would virtually disappear by 2040, and the per capita cost would just about stabilize. On the other hand, if Projection C were to be realized (with its total fertility rate of only 1.2, and its lower mortality and immigration rates), then population growth would disappear in Ontario by 2040, and aging would be the sole source of population-related increases in per capita cost. But even in that projection population growth would account



for the largest fraction of the increase until 2010, and it would be a virtual tie between the growth and aging components between 2010 and 2015. The role of population aging thus seems to have been overemphasized as an influence on the rate of increase in physician costs, and the role of population growth given less than its due.

## 7. APPLICATION OF THE AGE/COST PROFILES TO SELECTED COUNTRIES

We widen our investigation by applying the Ontario age/cost profiles to projections of the populations of fifteen countries. In doing so we do not assume that the profiles for those countries are exactly the same as the Ontario ones; that would be foolish. Our principal objective is to explore the effects on aggregate and per capita physician costs over a wide range of populations, holding the profiles constant so as to isolate “pure” demographic effects. To the extent, though, that collectively the Ontario profiles represent a set of physician services similar to those provided in the selected countries, the results may be interpreted as approximations to what one would obtain if country-specific profiles were available and applied. The classification of physicians will vary from country to country, and the services provided in categories that appear the same may in fact be quite different. In some cases apparently comparable categories may not exist at all. But what matters for our purposes is that overall the services provided by physicians be similar, so that even though the definitions of categories and their age/cost profiles may not be the same, the application of the differing sets of profiles to a given population would produce similar cost indexes. (The indexes measure changes through time, of course; we are not concerned with cost levels in the different countries.) We do emphasize, though, that the application of our fixed set of profiles must be viewed as providing no more than approximations

to what would be obtained using country-specific ones.

The set of countries we have chosen is somewhat arbitrary. It includes Australia, New Zealand, Japan, the United States, Canada, and ten European countries. The population projections we have used extend from 2000 to 2040. The ones for Canada were calculated using a projection program of our own (Denton, Feaver, and Spencer, 1994), with assumptions consistent with those underlying Projection A for Ontario; the projections for all other countries were taken from U.S. Census Bureau (2000).

Projected indexes of population and physician costs are shown in Table 3, together with a decomposition of the cost growth rates. The indexes have base value 100.0 in the year 2000, as in the earlier tables. They are reported for the years 2020 and 2040, together with average 5-year growth rates over the 20-year intervals 2000-2020 and 2020-2040.

There are some obvious patterns. Physician costs are projected to rise as a result of population change in all of the countries, both in the aggregate and per capita, and in both halves of the projection period. The increases in per capita costs over the first 20 years range from about 6 to 12 percent, the increases in aggregate costs from 6 to 28 percent. In most cases there are further increases in aggregate costs over the second 20 years of the projection period (exceptions are Japan, Italy, and Finland), and in all cases there are further increases in per capita costs.

It is clear that the influence of population aging is likely to be widespread among industrialized countries in the next several decades. In some, increases in the size of the population will also be a significant factor in the period 2000-2020. By the second half of the projection period, though, the effects of aging will dominate in almost all cases, if the projections are to be believed. Projections as far out as 40 years should obviously be interpreted with some

scepticism. Major increases in fertility or in developing-to-developed country migration rates could alter their accuracy substantially. Barring that, though, the average ages of the populations of the industrialized countries will continue on their upward trajectories.

Just how widespread the effects of aging on physician costs are likely to be is brought out in Table 4. Based on Table 3, Table 4 shows which of the two demographic effects on costs are the greater in each of the 2000-2020 and 2020-2040 periods. In the first period, population growth effects dominate outside Europe in Australia, New Zealand, the United States, and Canada, and inside Europe in Ireland and Norway; in all of the other nine countries (Japan plus the remaining European countries), aging effects dominate. In the second period, though, aging effects dominate everywhere except in the United States, where population growth is the much more important factor, and in Australia, where there is a tie. (In spite of the results obtained with Projections A and B for the province of Ontario, and discussed earlier, Canada as a whole falls into the aging dominance category in 2020-2040.)

## 8. APPLICATIONS TO SOME THEORETICAL POPULATIONS

We probe the effects of population change further by applying the age/cost profiles to some theoretical populations. The aim here is to get some idea of the outer bounds of the effects of differences in age distribution. With that in mind, we choose four alternatives. The first, which we refer to as TP1, is a stationary population based on the Statistics Canada 1991 life tables for Ontario; the total fertility rate for this population is at the natural replacement level of about 2.1. The second theoretical population, TP2, is also stationary, with a total fertility rate of about 2.3, and based on the 1931 Ontario life table, with its much higher mortality rates. The third

population, TP3, combines the TP2 mortality rates with a total fertility rate of 3.0; it is generated by computer simulation over a long enough period to put it on a steady state growth path, with constant age distribution. The fourth population, TP4, is generated in the same way, but has the TP1 mortality rates and a total fertility rate of 1.0, which puts it on a steady state path of decline; it would extinguish itself eventually but we are interested only in its age distribution as it moves in that direction. The results of applying the age/cost profiles to these four populations are shown in Table 5, in index form, together with the 5-year growth rates of the indexes. (The populations are scaled so that they all have the same size, and differ only in their age distributions.) The median ages of the populations are shown also in Table 5. TP1 is used as a reference population for the cost indexes, and thus has index value 100.0.

The median ages of the TP populations differ markedly, reflecting the long-term consequences of the differences in fertility and mortality rates. The greatest difference is between the 29.2 median age in TP3 and the 58.6 median in TP4. That difference is mirrored in the difference in the cost indexes for the two populations: the index for TP3 is 83.8, the index for TP4 130.4, implying that moving from the one age distribution to the other increases the total cost of physician services by 56 percent. Thus age distribution can have a huge impact on physician costs. But these are strictly theoretical populations, constructed deliberately to produce extreme results. We present them to demonstrate that population aging has the potential to bring about very large increases in physician costs. Whether it will or not in any particular country and period is another matter. The future effects of aging are a legitimate concern, as these calculations show, but care should be taken not to give them undue emphasis by assuming the worst. None of the actual demographic situations that we have examined comes close to the

extremes represented by the differences among the theoretical populations.

## 9. DIFFERENTIAL EFFECTS ON PHYSICIAN CATEGORIES

We have been concerned exclusively to this point with the effects of population change on the total cost of physician services. Now we return to Ontario and inquire into the effects on particular categories of physicians. In doing so we make use of equation (2), applied to the nineteen categories with which we have been working. Table 6 shows the Ontario indexes for those categories, and major combinations of them, at 10-year intervals from 1980 to 2040, with populations based on Projection A in the case of the future indexes. Table 7 shows the percentage distributions of total costs among the nineteen categories for the same period. (Since population growth affects all categories in the same proportion, the changes in distribution in Table 7 are the result entirely of population aging.)

It is clear from the tables that however much or little population aging may affect total cost, it will have quite dissimilar effects on some of the individual categories. Total cost is projected to increase by 59 percent but for some categories the increases are much greater and for some much less: Ophthalmology and Thoracic/Cardiovascular Surgery are at one extreme, with projected increases in excess of 100 percent; Pediatrics is at the other, with a projected increase of only 5 percent, reflecting the continuation of low fertility rates and relatively small numbers of children in the population. Next from the bottom are Obstetrics/Gynecology, with a projected increase of about 18 percent, and Psychiatry, with a projected increase of 28 percent.

The cost index for General Practice is roughly similar to the overall index, increasing by about 54 percent from 2000 to 2040, and the share of General Practice in total cost varies little

over the projection period, and indeed over the period 1980-2000 also. Based on population effects alone, and considering the full period from 1980 to 2040, the percentage share of General Practice in total physician costs varies within the narrow range 36.4 to 38.6, and the combined share of the specialized categories within the range 61.4 to 63.6. In view of the major shifts in age distribution that have taken place or will take place over the 60-year period, that is perhaps a surprising result. Perhaps surprising also is the relative stability of the shares of the two major divisions within the specialty categories, Medical and Surgical: the first varies only from 36.0 to 37.4 percent of total physician cost over the same period, the second from 16.8 to 18.0. Thus while population aging induces large differences in the rate of growth of requirements and in cost shares at the level of the nineteen individual categories of physicians, at the level of the three major divisions within the profession the differences are small.

## 10. SUMMING UP

We have explored the effects of population change on the costs of physician services, exploiting for that purpose a data set for the province of Ontario in which physician billings are classified by age and sex of patient and category of physician. We have converted that data set to a set of age/cost profiles and applied the profiles to a range of populations, including historical and projected Ontario populations, the projected populations of fifteen countries, and some theoretical populations. In all cases we have assumed other influences on physician costs to be constant and focused our analysis on “pure” demographic effects. Actual physician costs have been and will be affected by advances in medical knowledge and technology, changes in physician practice norms, relative prices, the characteristics of health care insurance plans, and

other nondemographic factors. But population change – in particular population aging – is prominent in the public mind as a growing source of pressure on health care costs, even though the timing and extent of its effects may not be clearly understood. Our aim has been to provide some illumination of the role that population change plays with respect to the physician component of the national health care budget.

Population growth has been more important than aging as a source of increase in physician costs in Ontario in the past four decades, and barring a major future decline in fertility rates it is likely to be the more important source over the next four. In total, physician costs are likely to rise no more rapidly between now and 2040 than they did between 1960 and 2000, and in all likelihood they will rise at a markedly slower pace, whichever of our population projections one uses for the calculation. Population aging will tend to increase physician costs in Ontario, but at only a moderate rate, by historical standards. The population-induced increases will be much greater than average for some categories of physicians, much less for others, but the overall proportionate distribution of costs between physicians in general practice and those in specialized practice, and within the latter between medical and surgical specialties, will be relatively stable.

Of the fifteen industrialized countries that we have considered, population growth is projected to dominate aging as a source of cost increase in six, over the period 2000 to 2020. Between 2020 and 2040, population growth is projected to be the dominant source in the United States, with aging and growth of about equal importance in Australia, but aging is projected to dominate in all others. In every country, the overall rate of increase resulting from population change is projected to be lower in 2020-2040 than in 2000-2020. Needless to say, these conclusions depend on the assumptions underlying the population projections and the

applicability of the age/cost profiles we have used as approximations to the true profiles for individual countries. In the large, though, we think they probably represent a reasonable statement of outlook for the industrialized world over the next several decades.

The calculations we have done for four theoretical populations demonstrate that, in the extreme, population aging has the potential to produce very large differences in overall physician costs per capita from one population to another. However, the extremes are unlikely to be realized in real-world situations; the effects of aging are likely to be smaller, and to occur relatively slowly, over quite long periods of time. Moreover, strong demographic pressure on costs is likely to produce compelling incentives to find alternative, less costly ways of delivering health care services, and so relieve the pressure. But that is another story.



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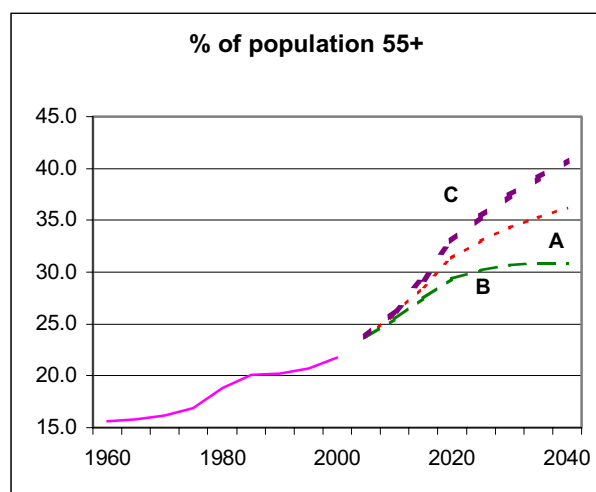
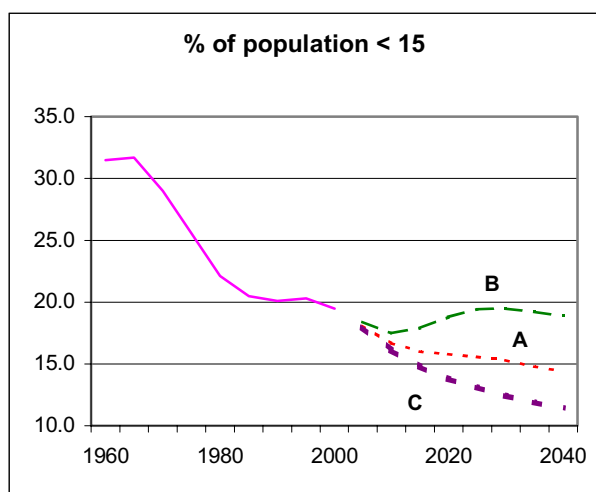
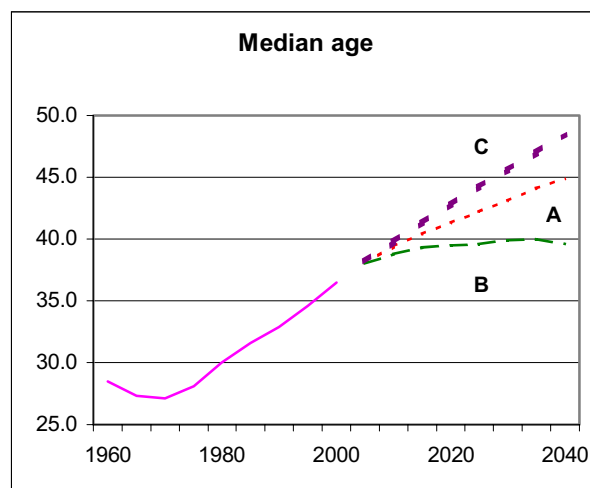
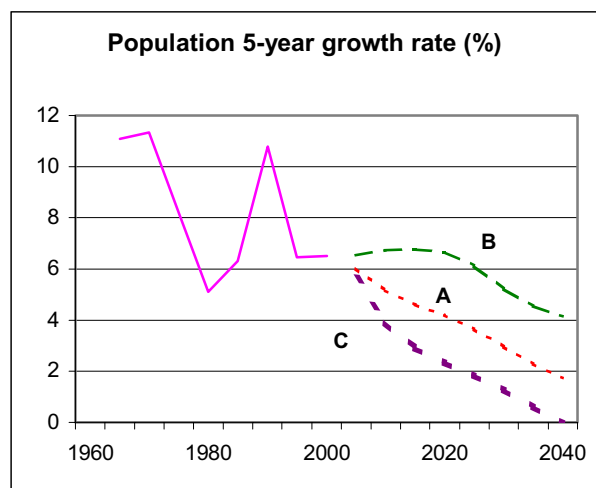
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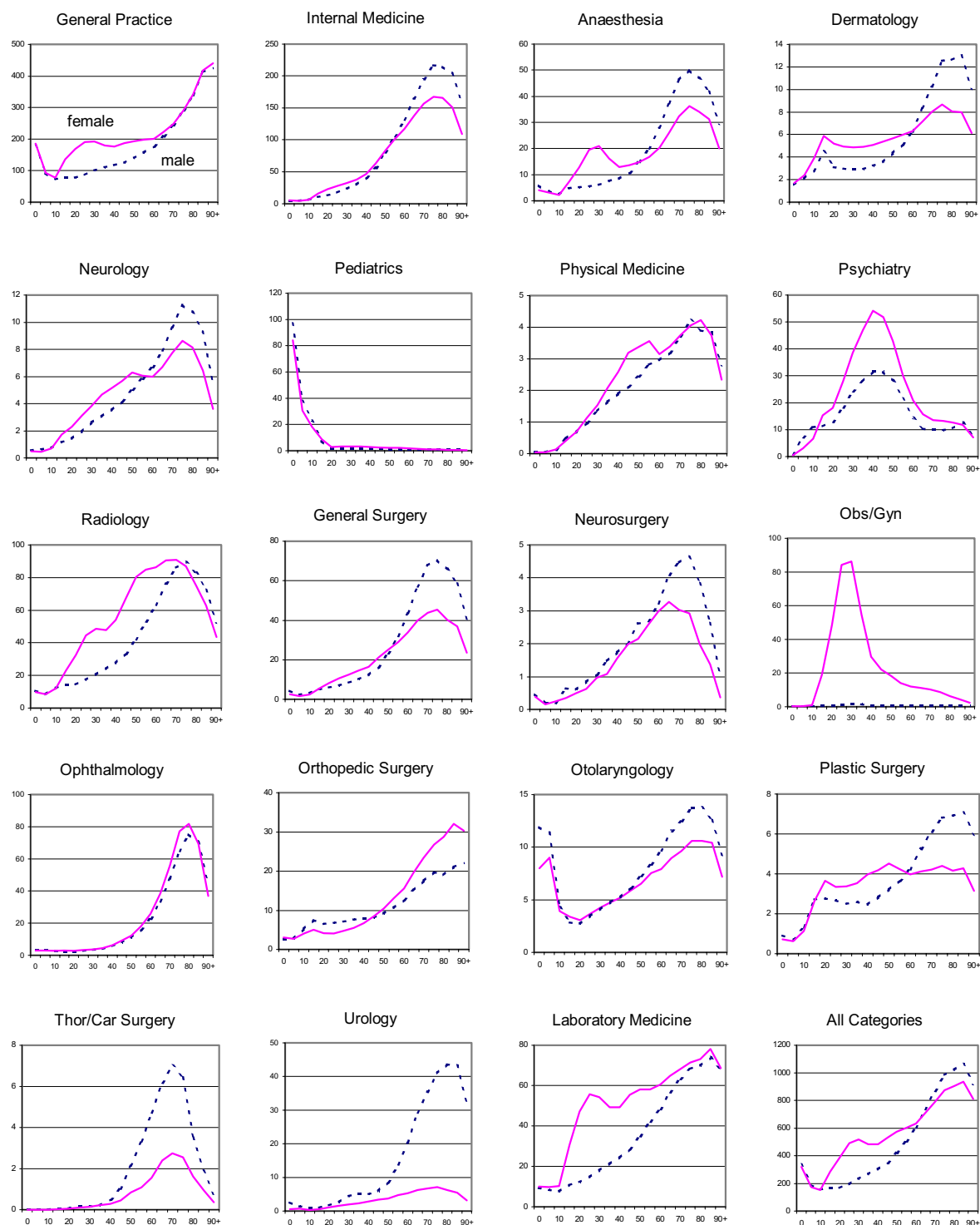
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FIGURE 1: POPULATION AGING IN ONTARIO, ACTUAL AND PROJECTED, 1960-2040:  
SELECTED INDICATORS



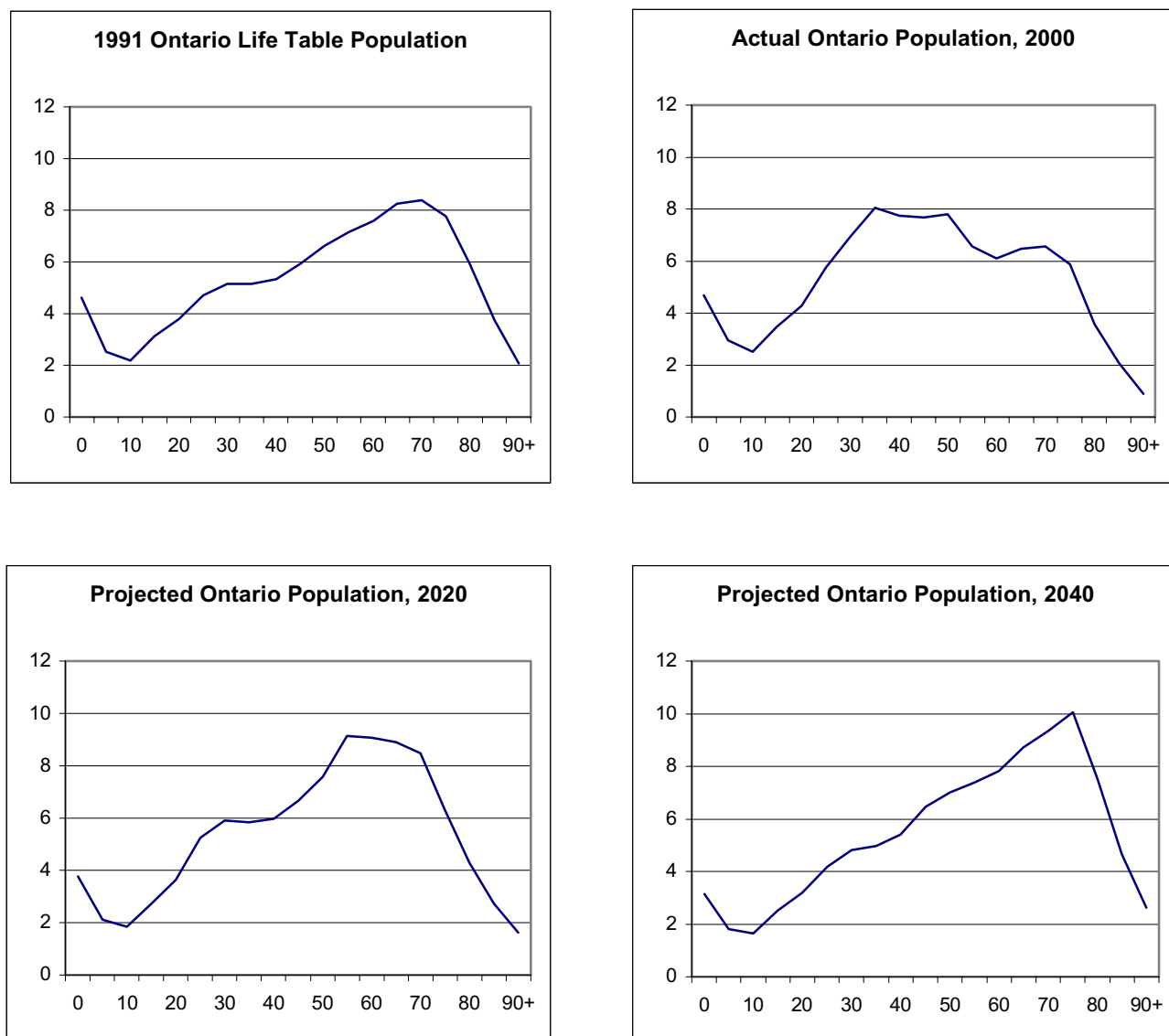
Note: Alternative population projections are identified as A, B, C. See note to Table 1.

FIGURE 2: AGE/COST PROFILES FOR PHYSICIAN SERVICES, BY CATEGORY OF PHYSICIAN:  
ONTARIO, 1995



Note: Five-year age groups are indicated on the horizontal axes: 0 for 0-4, 5 for 5-9, etc.; the oldest group is 90+. Costs per capita (in dollars) are shown on the vertical axes.

FIGURE 3: PERCENTAGE DISTRIBUTION OF THE AGGREGATE COSTS OF PHYSICIAN SERVICES, BY AGE GROUP: SELECTED POPULATIONS



Note: Age groups are identified as in Figure 2. Percentages of total aggregate cost are shown on the vertical axes. The populations in 2020 and 2040 are based on Projection A.

TABLE 1: THE POPULATION OF ONTARIO AND ITS CHARACTERISTICS, ACTUAL AND PROJECTED, 1960-2040

	<i>Population</i>				<i>Age Distribution (%)</i>		
	Number ('000)	Index (2000= 100.0)	5-year growth rate (%)	Median age	Under 15	55-74	75 and older
<i>Actual Population</i>							
1960	6220	53.3	---	28.5	31.5	12.8	2.8
1965	6909	59.2	11.1	27.3	31.7	12.8	3.0
1970	7692	65.9	11.3	27.1	29.0	13.1	3.1
1975	8320	71.2	8.2	28.1	25.6	13.6	3.3
1980	8745	74.9	5.1	30.0	22.1	15.1	3.7
1985	9297	79.6	6.3	31.6	20.5	16.0	4.1
1990	10300	88.2	10.8	32.9	20.1	15.7	4.5
1995	10965	93.9	6.5	34.6	20.3	15.9	4.8
2000	11678	100.0	6.5	36.5	19.5	16.2	5.6
<i>Projection A</i>							
2005	12382	106.0	6.0	38.1	18.1	17.7	6.1
2010	13021	111.5	5.2	39.4	16.7	19.6	6.4
2015	13619	116.6	4.6	40.4	16.0	21.9	6.7
2020	14189	121.5	4.2	41.3	15.8	24.2	7.2
2025	14709	126.0	3.7	42.2	15.6	24.6	8.4
2030	15148	129.7	3.0	43.1	15.3	24.6	9.7
2035	15495	132.7	2.3	44.1	14.8	24.1	11.2
2040	15762	135.0	1.7	44.9	14.4	23.5	12.7
<i>Projection B</i>							
2005	12440	106.5	6.5	38.0	18.4	17.6	6.1
2010	13278	113.7	6.7	38.8	17.5	19.2	6.3
2015	14176	121.4	6.8	39.3	17.9	21.2	6.3
2020	15119	129.5	6.7	39.5	18.8	22.8	6.6
2025	16044	137.4	6.1	39.6	19.4	22.7	7.5
2030	16884	144.6	5.2	39.9	19.5	22.3	8.4
2035	17653	151.2	4.6	40.0	19.2	21.6	9.3
2040	18385	157.4	4.1	39.6	18.9	20.8	10.1
<i>Projection C</i>							
2005	12336	105.6	5.6	38.2	18.0	17.7	6.1
2010	12819	109.8	3.9	39.8	16.1	19.8	6.5
2015	13191	113.0	2.9	41.3	14.8	22.5	6.9
2020	13498	115.6	2.3	42.8	13.8	25.3	7.7
2025	13745	117.7	1.8	44.2	13.1	26.1	9.3
2030	13920	119.2	1.3	45.6	12.4	26.4	11.0
2035	14005	119.9	0.6	47.0	11.9	26.1	13.0
2040	14000	119.9	0.0	48.5	11.4	25.6	15.2

Note: Projection A--"standard"; Projection B--higher fertility, mortality, and immigration; Projection C--lower fertility, mortality, and immigration. See text for details.

TABLE 2: THE EFFECTS OF POPULATION CHANGE ON THE AGGREGATE AND PER CAPITA COSTS OF PHYSICIAN SERVICES IN ONTARIO, 1960-2040

	Index of costs (2000=100.0)		Aggregate 5-year growth rate (%)		
	Aggre- gate	per capita	Total	--- Resulting from ---	
				Population growth	Population aging
<i>Actual Population</i>					
1960	47.4	89.1	--	--	--
1965	52.3	88.3	10.1	11.0	-0.9
1970	58.0	88.1	11.1	11.3	-0.2
1975	63.9	89.8	10.2	8.2	2.0
1980	69.4	92.7	8.5	5.2	3.3
1985	75.8	95.2	9.2	6.4	2.8
1990	85.3	96.7	12.6	10.9	1.7
1995	92.4	98.4	8.3	6.5	1.8
2000	100.0	100.0	8.3	6.6	1.7
<i>Projection A</i>					
2005	108.1	102.0	8.1	6.1	2.0
2010	116.4	104.4	7.6	5.2	2.4
2015	124.7	107.0	7.2	4.7	2.5
2020	133.1	109.5	6.7	4.2	2.5
2025	141.1	112.0	6.0	3.7	2.3
2030	148.3	114.3	5.1	3.0	2.1
2035	154.4	116.3	4.1	2.3	1.8
2040	159.0	117.8	3.0	1.7	1.3
<i>Projection B</i>					
2005	108.5	101.9	8.5	6.6	1.9
2010	118.0	103.8	8.8	6.8	2.0
2015	128.1	105.5	8.5	6.8	1.7
2020	138.3	106.9	8.0	6.7	1.3
2025	148.3	107.9	7.2	6.2	1.0
2030	157.4	108.8	6.1	5.2	0.9
2035	165.6	109.5	5.2	4.6	0.6
2040	172.9	109.8	4.4	4.1	0.3
<i>Projection C</i>					
2005	107.8	102.1	7.8	5.7	2.1
2010	115.1	104.9	6.8	4.0	2.8
2015	122.1	108.1	6.1	3.0	3.1
2020	129.0	111.6	5.7	2.4	3.3
2025	135.6	115.2	5.2	1.9	3.3
2030	141.5	118.7	4.3	1.3	3.0
2035	146.2	121.9	3.3	0.6	2.7
2040	149.2	124.5	2.1	0.0	2.1

Note: See note to Table 1.

TABLE 3: PROJECTED POPULATION CHANGE AND ITS EFFECTS ON THE AGGREGATE AND PER CAPITA COSTS OF PHYSICIAN SERVICES IN SELECTED COUNTRIES, 2000-2040, ASSUMING ONTARIO AGE/COST PROFILES

Country	Year	Index of population (2000 = 100.0)	Cost of physician services				
			Index (2000=100.0)		Mean 5-year growth rate in previous 20 years (%)		
			Aggregate	Per capita	Total	--- Resulting from ---	
						Population growth	Population aging
Australia	2020	116.9	128.0	109.5	6.4	4.0	2.4
	2040	125.4	147.3	117.5	3.6	1.8	1.8
Canada	2020	115.2	127.7	110.8	6.3	3.7	2.6
	2040	122.1	145.9	119.5	3.4	1.5	1.9
Denmark	2020	104.4	112.0	107.3	2.9	1.1	1.8
	2040	105.6	118.5	112.2	1.4	0.3	1.1
Finland	2020	101.3	111.8	110.4	2.8	0.3	2.5
	2040	95.7	111.2	116.1	-0.1	-1.4	1.3
France	2020	104.2	112.6	108.0	3.0	1.1	1.9
	2040	102.6	118.2	115.3	1.2	-0.4	1.6
Germany	2020	103.3	112.3	108.8	3.0	0.8	2.2
	2040	100.3	115.8	115.5	0.8	-0.7	1.5
Ireland	2020	115.1	125.1	108.6	5.7	3.6	2.1
	2040	119.0	142.1	119.3	3.2	0.8	2.4
Italy	2020	96.4	105.9	109.9	1.5	-0.9	2.4
	2040	85.8	103.4	120.6	-0.6	-2.9	2.3
Japan	2020	97.5	109.1	111.9	2.2	-0.6	2.8
	2040	86.2	102.1	118.3	-1.7	-3.1	1.4
New Zealand	2020	119.0	128.1	107.6	6.4	4.5	1.9
	2040	127.3	149.5	117.4	3.9	1.7	2.2
Norway	2020	108.5	115.5	106.4	3.7	2.1	1.6
	2040	113.1	127.4	112.6	2.5	1.1	1.4
Spain	2020	98.1	108.3	110.3	2.0	-0.5	2.5
	2040	88.8	109.8	123.7	0.4	-2.5	2.9
Sweden	2020	100.6	108.8	108.2	2.1	0.1	2.0
	2040	97.3	110.3	113.4	0.3	-0.9	1.2
United Kingdom	2020	103.2	111.0	107.5	2.6	0.8	1.8
	2040	101.2	116.7	115.2	1.3	-0.5	1.7
United States	2020	118.0	126.0	106.7	5.9	4.2	1.7
	2040	137.0	152.4	111.1	4.8	3.8	1.0

Note: The population projection for Canada is by the authors, based on assumptions corresponding to those used in Projection A for Ontario. For all other countries, the projections are from the U.S. Census Bureau (2000).



TABLE 4: POPULATION GROWTH vs. AGING: THE LARGEST SOURCES OF PROJECTED INCREASES IN THE AGGREGATE COSTS OF PHYSICIAN SERVICES IN SELECTED COUNTRIES, 2000-2040

Country	Largest source of population-based increase	
	2000-2020	2020-2040
Australia	growth	growth/aging
Canada	growth	aging
Denmark	aging	aging
Finland	aging	aging
France	aging	aging
Germany	aging	aging
Ireland	growth	aging
Italy	aging	aging
Japan	aging	aging
New Zealand	growth	aging
Norway	growth	aging
Spain	aging	aging
Sweden	aging	aging
United Kingdom	aging	aging
United States	growth	growth

Note: The classification in this table is based on Table 3.

TABLE 5: THE EFFECTS OF AGE DISTRIBUTION ON THE AGGREGATE COSTS OF PHYSICIAN SERVICES IN SELECTED THEORETICAL POPULATIONS, ASSUMING ONTARIO AGE/COST PROFILES

Theoretical population	Median age	Cost of physician services	
		Index (TP1 = 100.0)	5-year growth rate
TP1	39.4	100.0	0.0
TP2	34.8	91.2	0.0
TP3	29.2	83.8	4.3
TP4	58.6	130.4	-11.7

Note: TP1 and TP2 are stationary populations based, respectively, on the 1991 and 1931 Ontario life tables. TP3 is a steady-state growth population generated by computer simulation, assuming the 1931 life table mortality rates and a total fertility rate of 3.0. TP4 is a population in steady-state decline; it is generated in the same way but assuming the 1991 life table mortality rates and a total fertility rate of 1.0. The male/female ratio at birth is set at 1.055 in all cases. The populations are scaled so as to have the same size for purposes of the calculations, and thus differ only in their age-sex distributions.

TABLE 6: THE EFFECTS OF POPULATION CHANGE ON THE AGGREGATE COSTS OF PHYSICIAN SERVICES IN ONTARIO, 1980-2040, BY CATEGORY OF PHYSICIAN

	Based on actual population			Projected			
	1980	1990	2000	2010	2020	2030	2040
(Indexes: 2000 = 100.0)							
<i>General Practice</i>	71.1	86.4	100.0	114.8	129.2	142.8	153.5
<i>Medical Specialties</i>	68.0	84.1	100.0	117.5	135.3	151.1	161.3
Internal Medicine	64.4	81.3	100.0	122.6	147.0	169.7	185.0
Anaesthesia	68.0	85.0	100.0	118.0	138.8	158.3	170.8
Dermatology	71.9	85.8	100.0	115.9	131.1	146.1	156.5
Neurology	66.2	82.9	100.0	118.3	136.2	152.9	163.8
Pediatrics	84.7	95.2	100.0	99.0	103.9	106.2	105.2
Physical Medicine	64.8	81.9	100.0	119.3	137.0	152.8	163.7
Psychiatry	68.3	84.8	100.0	112.0	118.9	124.5	128.1
Radiology	68.1	84.0	100.0	118.5	136.4	151.0	160.1
<i>Surgical Specialties</i>	68.4	85.3	100.0	117.4	136.9	155.3	167.6
General Surgery	65.5	82.3	100.0	121.2	144.7	166.1	179.3
Neurosurgery	66.0	82.6	100.0	119.7	139.6	156.2	165.0
Obstetrics/Gynecology	77.3	95.7	100.0	107.4	114.8	116.3	117.6
Ophthalmology	62.5	80.1	100.0	122.7	150.7	184.3	208.3
Orthopedic Surgery	68.6	84.0	100.0	118.3	137.0	155.5	169.0
Otolaryngology	71.2	85.7	100.0	113.4	128.5	142.0	150.1
Plastic Surgery	71.2	86.0	100.0	116.2	130.4	143.1	152.2
Thoracic/Cardiovascular Surgery	62.8	80.1	100.0	126.4	160.6	188.9	201.7
Urology	63.6	81.4	100.0	122.7	150.6	178.4	196.5
<i>Laboratory Medicine</i>	69.4	85.4	100.0	117.0	133.0	146.7	156.6
<i>All Categories</i>	69.4	85.3	100.0	116.4	133.1	148.3	159.0

Note: The cost projections are based on population Projection A.

TABLE 7: THE EFFECTS OF POPULATION CHANGE ON THE DISTRIBUTION OF THE COSTS OF PHYSICIAN SERVICES IN ONTARIO, 1980-2040, BY CATEGORY OF PHYSICIAN

	Based on actual population			Projected			
	1980	1990	2000	2010	2020	2030	2040
	(Percentages of total cost)						
<i>General Practice</i>	38.6	38.2	37.7	37.2	36.6	36.3	36.4
<i>Medical Specialties</i>	36.0	36.2	36.7	37.0	37.3	37.4	37.2
Internal Medicine	12.1	12.5	13.1	13.8	14.4	15.0	15.2
Anaesthesia	3.3	3.3	3.3	3.4	3.5	3.5	3.6
Dermatology	1.2	1.1	1.1	1.1	1.1	1.1	1.1
Neurology	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Pediatrics	3.2	3.0	2.7	2.3	2.1	1.9	1.8
Physical Medicine	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Psychiatry	5.3	5.4	5.4	5.2	4.8	4.6	4.4
Radiology	9.6	9.6	9.8	9.9	10.0	10.0	9.8
<i>Surgical Specialties</i>	16.8	17.1	17.1	17.2	17.6	17.9	18.0
General Surgery	4.0	4.1	4.2	4.4	4.6	4.7	4.7
Neurosurgery	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Obstetrics/Gynecology	4.0	4.1	3.6	3.3	3.1	2.8	2.7
Ophthalmology	2.7	2.8	3.0	3.2	3.4	3.7	3.9
Orthopedic Surgery	2.0	2.0	2.1	2.1	2.1	2.2	2.2
Otolaryngology	1.6	1.5	1.5	1.5	1.5	1.5	1.4
Plastic Surgery	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Thoracic/Cardiovascular Surgery	0.2	0.2	0.2	0.2	0.3	0.3	0.3
Urology	1.2	1.3	1.3	1.4	1.5	1.6	1.6
<i>Laboratory Medicine</i>	8.6	8.6	8.6	8.6	8.6	8.5	8.4
<i>All Categories</i>	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: See note to Table 6.

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